Names: Maria Deepti, Dominic Andrew P., P. G. Sravani, Krishjeet Brar
Roll nos.: 2360413, 2360365, 2360429, 2360403

Problem Statement 1

Modelling and Analysis of a DC Motor for Drone Applications

Problem Statement: Design and simulate a basic DC motor model suitable for drone propulsion for lightweight UAV applications using Amesim. Analyse the speed-torque characteristics and the effect of varying supply voltage on motor RPM.

Project submission link (GitHub): [Project Source Link]

1. Aim of the Project:

To design, simulate, and analyze a DC motor model in Amesim for lightweight UAV propulsion, focusing on understanding its dynamic and steady-state behavior. The study aims to:

- Investigate the **speed-torque characteristics** of the motor under varying load conditions.
- Examine the effect of **different supply voltages** on the motor's RPM and overall performance.
- Evaluate the motor's suitability for **drone applications**, where high efficiency, low weight, and responsive control are critical.

2. Problem Statement and Proposed Simulation Approach

Lightweight UAVs and drones require highly efficient and responsive propulsion systems to achieve stable flight and maneuverability. Selecting an appropriate DC motor for such applications involves understanding its dynamic behavior, speed-torque characteristics, and performance under varying supply voltages.

Key challenges:

- Predicting how different voltages affect RPM.
- Ensuring that motor torque is sufficient to overcome aerodynamic drag.
- Modelling realistic mechanical loads and thermal effects.

1. **Modeling the DC Motor:**

- Creation of a **basic DC motor model** in Amesim using electrical and mechanical subsystems.
- Defining motor parameters such as resistance, inductance, back EMF constant, torque constant, and rotor inertia based on lightweight UAV requirements.

2. **Simulation Setup:**

- Applying **variable supply voltages** to study the effect on motor RPM and torque output.
- Introduction of different **load conditions** to analyze the speed-torque characteristics.
- Implementation of sensors within the model to measure RPM, torque, current, and voltage.

3. **Analysis:**

- Plotting **speed vs. torque curves** to understand the motor's operating range.
- Evaluating **RPM variations** under different supply voltages to determine efficiency and responsiveness.
- Comparing simulation results with theoretical predictions to validate model accuracy.

4. **Performance Evaluation:**

- Assessing the motor's suitability for drone propulsion by considering factors such as **lightweight design, efficiency, and control response**.
- Identifying optimal operating voltage ranges and load conditions for efficient UAV performance.

3. System Modelling and Simulation Design in Amesim

The complete system design in Siemens Amesim consists of **electrical,** thermal, and mechanical subsystems interconnected to replicate real motor behaviour.

Model Components :

- **DC Machine (EMDSEDC01 –** Separately Excited DC Motor)
- **Voltage Sources (EBVS01, EBZV01, EB3N01, UD00)** for supplying armature and field circuits.
- **Rotary Load (MECRL0 – 2 ports)** to simulate propeller load.
- **Torque Source (TORQC)** to apply step torque disturbances.
- **Thermal Source (THTS1)** to account for resistive and iron losses.
- **Control Constants (CONS00, W000)** for reference settings.

Simulation Workflow:

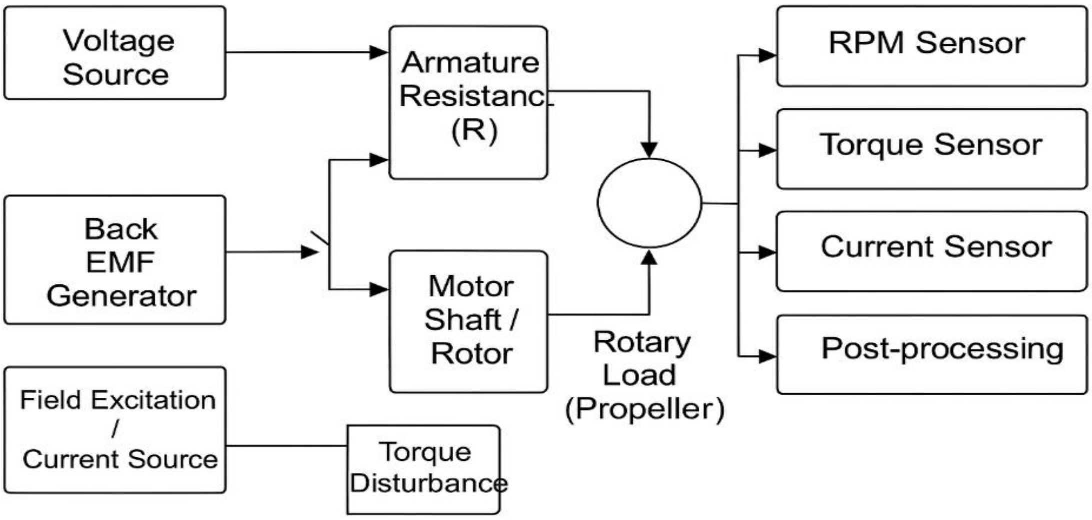
1. Supply voltage applied to armature winding.
2. Field excitation current controls flux.
3. Motor shaft drives rotary load (representing propeller).

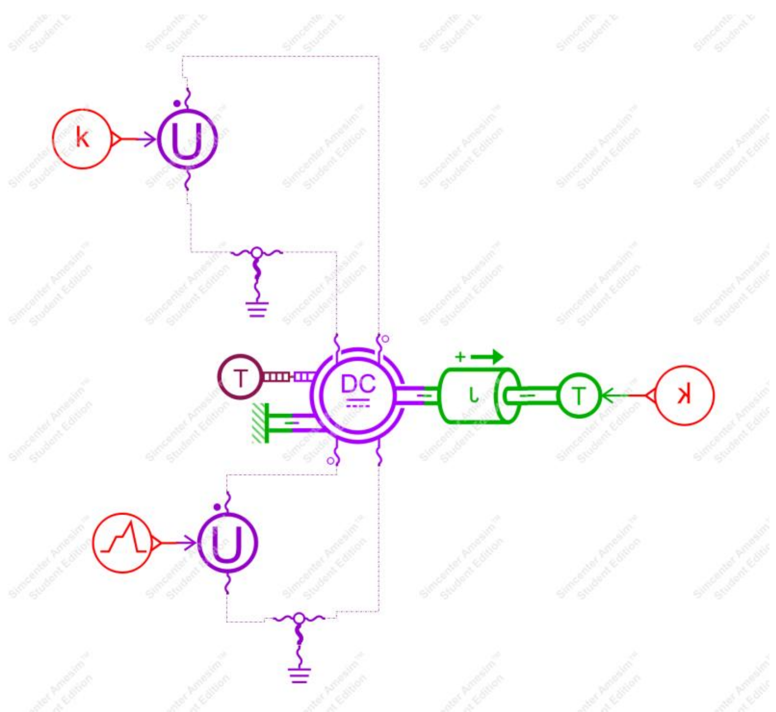
4. Torque disturbance applied to replicate aerodynamic resistance.

5. Outputs measured at motor shaft:

    - RPM (rev/min)
    - Torque (Nm)
    - Current (A)

DC MOTOR SIMULATION IN AMESIM





4. Selection and Justification of Subsystems/Blocks

Submodel Code	Subsystem	Role	Justification for UAV Motor Simulation
W000	Constant	Provides fixed values (e.g., scaling)	Required for parameter initialization.
UD00	Signal Voltage Source	Supplies input waveform to motor	Enables step/variable voltage excitation.
TORQC	Torque Source	Applies external torque	Simulates aerodynamic resistance from drone propeller.
THTS1	Thermal Source	Adds heating effect	Models motor temperature rise due to losses.
MECRL0	Rotary Load (2 ports)	Represents propeller load	Converts motor torque to rotational motion.
EMDSEDC01	DC Machine	Core motor dynamics	Captures armature/field interactions.
EBZV01 / EBVS01 / EB3N01	DC Sources	Battery supply modules	Simulate UAV battery pack supply.
CONS00	Control Constant	Fixed inputs	Ensures system reference settings are maintained.

5. Parameter Settings, Boundary Conditions, and Simulation Setup

Motor Parameters (from Amesim setup)

- Armature Resistance (Ra): 0.6 Ω
- Armature Inductance (La): 0.012 H
- Field Resistance (Rf): 40 Ω
- Field Inductance (Lf): 1 H
- Electromotive constant (Ke): 0.18 Vs/A/rad

- Moment of Inertia (J): 1 kg·m²
- Friction Coefficient: 0 (ideal UAV motor assumption)

Load Parameters

- Rotary Load: Propeller-equivalent inertia.
- Torque disturbances: Applied step loads to mimic real propeller air resistance.

Simulation Settings

- Time duration: 0–50 s
- Integration step: Adaptive (Amesim default)
- Boundary Conditions:
    - Initial RPM = 0
    - Supply voltages = 100V, 200V, 300V
    - Load torque = 10 Nm

6. Results, Plots, and Interpretation

1. Shaft Speed vs Time

- At **100V**, RPM stabilizes at ~680 rev/min.
- At **200V**, RPM stabilizes at ~740 rev/min.
- At **300V**, RPM stabilizes at ~800 rev/min.
- Result: Motor speed is **directly proportional to supply voltage**.

2. Field Winding Current vs Time

- At 0–20s: Field current constant ~0.4 A → stable flux.
- At 20–30s: Increased excitation to 0.8 A → torque and RPM rise.
- After 30s: Speed stabilizes at higher RPM (~1600 rev/min).
- Result: **Higher excitation strengthens field flux**, improving torque generation.

3. Speed–Torque Characteristics

- Torque increases initially, then stabilizes as speed rises.
- At higher voltages, the **speed–torque curve shifts upward**.
- UAV Relevance: At constant load torque, increasing supply voltage increases RPM → suitable for altitude/thrust control.

7. Conclusion and Inference Drawn from Simulation

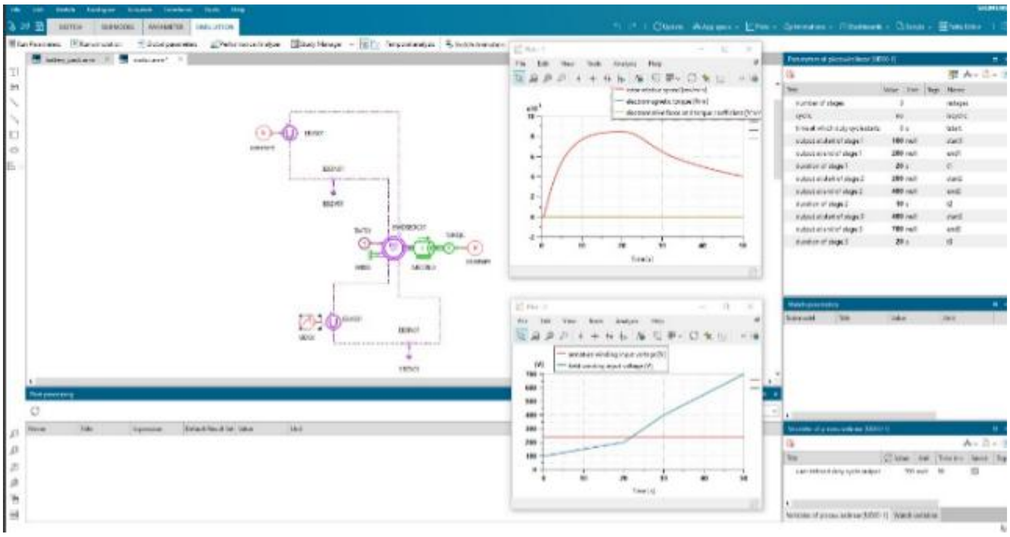
- The DC motor model was successfully designed and simulated in Siemens Amesim.
- Simulation confirms:
    - Voltage control effectively regulates motor RPM.
    - Field current adjustment enhances torque capacity.
    - Motor dynamics are suitable for UAV propulsion, where quick thrust response is essential.
- UAVs benefit from such motors due to lightweight construction, efficiency, and controllability.

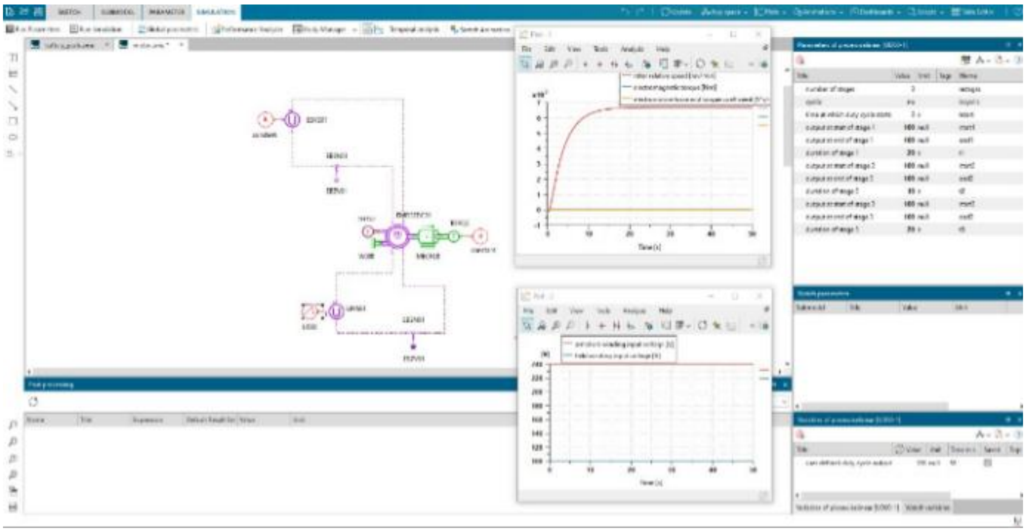
Final Inference:

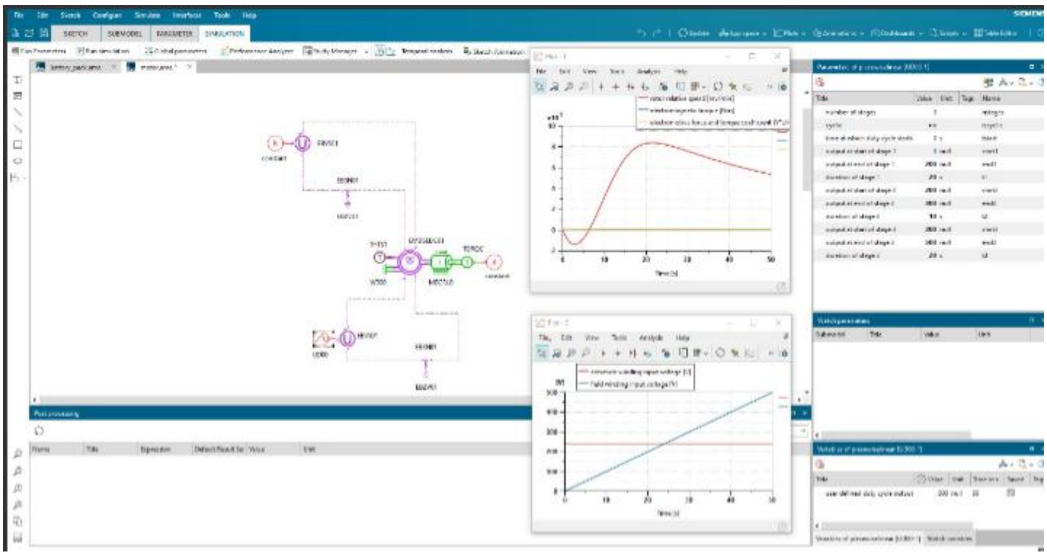
The simulation validates that a separately excited DC motor provides the required speed–torque characteristics for lightweight UAV propulsion and demonstrates that battery voltage variation is a practical method for altitude and thrust control in drones.

Names: Maria Deepti, Dominic Andrew P., P. G. Sravani, Krishjeet Brar
Roll nos.: 2360413, 2360365, 2360429, 2360403

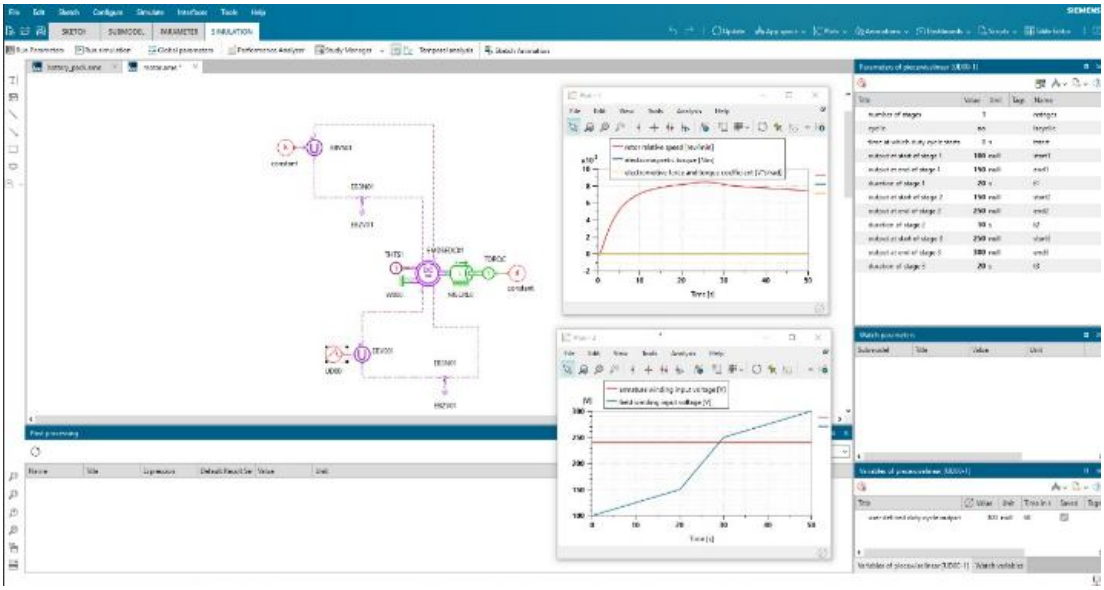
Screenshots:

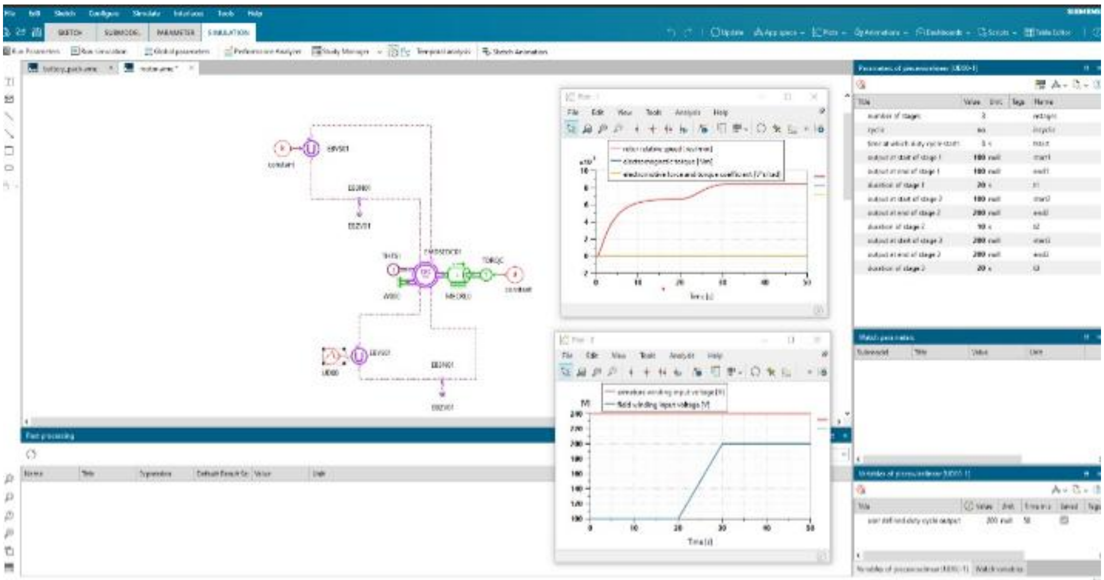






Names: Maria Deepti, Dominic Andrew P., P. G. Sravani, Krishjeet Brar
Roll nos.: 2360413, 2360365, 2360429, 2360403





Overall Conclusion:

The DC motor simulation demonstrates that the motor can provide reliable thrust for lightweight UAVs while allowing precise speed control through voltage variation. The speed-torque relationship and voltage-RPM behavior align with theoretical expectations, confirming the suitability of the selected motor for small drone propulsion systems.